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In the six month period from January 1, to June 30, 1965, the personnel shifts instituted during the first sixth month period were finalized. During this period, the work was carried on mainly by Dr. Melvin Schwartz and three graduate students. One of the students worked with Dr. H. Chiu on some problems in general relativistic fluid dynamics. Another worked with Dr. M. Isom on a problem concerning the gravitational stability of self-gravitating gas clouds. The latter work is being aimed at considerations of star formation. A third student has been working with Dr. M. Schwartz on solar wind flow problems. The students' efforts have not as yet produced concrete results since their major effort has gone into learning theory and calculational techniques.

During this last six month period, the bulk of the research work has centered on studying the problem of solar wind flow around the earth under the direction of Dr. Schwartz. We have extended Ferraro's 1952[1] model of a collisionless neutral plasma expanding into a static external magnetic field. Ferraro[1] considered a two fluid collisionless plasma constrained to move in a plane perpendicular to a unidirectional magnetic field. Approximate local neutrality was assumed and also that all variables varied only in the direction of the combined one fluid flow. Asymptotic electric and magnetic fields were assumed to vanish. The net result was a one-dimensional single fluid flow with a current flowing at right angles to the stream direction. The above ingredients have been extended to two cases of two dimensional single fluid flow.

In one case, we consider that the resultant single fluid flow is axisymmetric and radial in the plane perpendicular to a uni-directional magnetic field. The current is cylindrical, at right angles to the radial flow. All variables are assumed to have only a radial dependence. This case was motivated by considering an analogue to the Chapman-Ferraro, cylindrical sheet flow[2].

In Ferraro's one dimensional case, the assumption of exact local neutrality can only be approximately satisfied with non-constant flow. In two dimensions, however, exact local neutrality can be compatible with non-constant flow. Assuming exact local neutrality in certain specialized two dimensional cases permits one to obtain exact solutions.

As one might expect in the radial case, pile-up problems develop at a stagnation radius (as well as asymptotic divergences). Such piling up would probably not occur with a sheet approach where one can allow for reversal of sheet motion as discussed by Ferraro.

An interesting solution arises if one assumes that the differential equations hold only over a finite region bounded by two concentric circles. For a radial out-flow, a decreasing magnetic field results, while for a radial in-flow an increasing magnetic field results.

A second generalization considers a two dimensional meridian plane flow. The current is assumed to be perpendicular to the meridian plane and the magnetic field is assumed to be entirely in the meridian plane. If exact local neutrality is assumed and certain field components vanish asymptotically, then exact steady state solutions become possible. These will involve superpositions of multipole fields. Such solutions are capable of describing the two dimensional flow around a two-dimensional magnetosphere with a tail. Such solutions are also capable of exhibiting spatial oscillations up-stream from the magnetopause. The numerical exploration of these solutions is presently under way.

If the solar wind is considered as a cold collisionless plasma then it is not obvious that an isotropic relation between $\vec{B}$ and $\vec{H}$ should be used since the continuum magnetic moment per unit volume in the solar wind can be of the same order of magnitude as $\vec{B}$ or $\vec{H}$. One of the students has been set to work investigating this point in a one-dimensional flow regime. The main goal at present is to see if an unsymmetrical solitary wave solution exists for Alfven numbers greater than two. No definitive results have been obtained as yet - partly because of the difficulty in finding an appropriate set of initial data which can be used with a manageable convergent computation scheme. Concrete results are, however, expected in the near future. The differential equations being studied are four in number, coupled and non-linear, and admit but two integrals. Hence, numerical solution is required. At the moment, it is expected that the restriction that the Alfven number lie between one and two, as found in the model used by Adlam and Allen(3) and Davis et al(4) will not obtain.

Technical reports relating to the above research are now in the process of being written.

REFERENCES

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3. J. H. Adlam and J. E. Allen, Phil. mag. 3, 448 (1958)

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